

Jeffreys maintained that the *Cercariæ* found in *Succinea* were the sexually immature representatives of the common liver-fluke (*Fasciola hepatica*), which, I may observe, has some twenty times been found infesting the human body. At the time in question I maintained that Mr. Jeffreys's opinion had no foundation in fact, as the negative data supplied by Moulinié and Leuckart strongly went to prove. It now turns out, from the experimental proofs recently afforded by Dr. Ernst Zeller, that the cercarian contents of *Leucochloridium* found in *Succinea* attain sexual maturity in the intestines of various insectivorous birds of the family Sylviadæ. I am indebted to Mr. Dallas for first calling my attention to this discovery. (See Ann. Nat. Hist. for Feb. 1875, p. 146; from Humbert, in Bibl. Univ., Bull. Sci. 1874, p. 366; also Zeller in S. & K. Zeitsch. für wiss. Zool. vol. xxiv. p. 564, 1874.) In connexion with any explanation of the rapid appearance of fluke-disease amongst animals in particular districts, it is especially worthy of remark that the *Cercariæ* of *Distoma macrostoma* pass into the sexually mature condition in a few days after their change of residence has been effected, whilst in less than a week's time the formation of ova has already commenced.

In conclusion, I ought perhaps to apologize for having introduced so many remarks of a practical nature into a paper otherwise purely zoological; but the supposed extreme rarity of our *Distoma crassum*, its apparently formidable character as a human guest, and the special precautions that appear to be necessary against infection have together seemed to me to be a fair excuse for sounding a note of warning to naturalists and others whose rambles or professional duties may happen to carry them to the shores of the Chinese and other eastern seas.

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Similitudes of the Bones in the Enaliosauria. By HARRY GOVIER SEELEY, F.L.S., F.G.S., Professor of Physical Geography in Bedford College, London.

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## PART I.

### THE RESEMBLANCES OF ICHTHYOSAURIAN BONES TO THE BONES OF OTHER ANIMALS.

#### § 1. *The Mammalian Characters of Ichthyosaurus.*

A SKULL of *Ichthyosaurus* could not easily be changed into that of a mammal; for though Cetaceans offer close resemblance of

*form*, especially in the snout, the lateral position of the exterior nares in *Ichthyosaurus*, in front of the large circumscribed circular orbits, necessitates the enormous lateral development of the premaxillaries and a backward position of the maxillary bones. The lateral relation of the premaxillary bones in *Ichthyosaurus* divides them proximally, and allows the nasal bones a large space in which to elongate and widen between them; while in Porpoises (supposing the bones correctly determined) the nasal bones are small, and only just indent the premaxillary bones behind, and the premaxillary bones, drawn together mesially, allow the maxillary bones to extend external to them along their length, and to carry the teeth. In early life Porpoises, like *Ichthyosaurs*, carry their teeth in a groove instead of in sockets.

Wagler and other naturalists have compared the foramen parietale of *Ichthyosaurs* to the spiracles of Porpoises. And as the foramen descends obliquely forward into the skull, the structures have characters in common. If, then, we suppose the perforations to have become larger with functional activity in the Porpoise and more nearly vertical than in *Ichthyosaurus*, so as to have advanced forward through the frontal bones, then the median premaxillary bones of the Porpoise would have to be called nasals to bring them into harmony with *Ichthyosaurus*, while the maxillary bones would become the premaxillaries. But however plausible this interpretation looks in the skull seen from above, it becomes untenable on turning to the palate, where in both types (using the usual nomenclature) the premaxillary bones form the end of the snout, and are parted by the vomers behind, while the maxillary bone in both carries teeth and extends back beyond the alveoli.

In those Porpoises in which the occipital condyles blend into one long crescent, the single articulation is entirely made by the exoccipital bones, excluding the basioccipital; while in *Ichthyosaurus* the basioccipital forms the entire condyle and excludes the exoccipital bones.

In the Elephant the external nostrils are far back, but the nasal bones are entirely behind them; and, after the manner of all mammals except the true Whales, the maxillary bones meet mesially on the palate, which they never do in *Ichthyosaurs*.

The centrum of a vertebra is not usually quite so long in *Ichthyosaurus* as in Porpoises, and differs in being deeply biconcave (as in fishes), in not having epiphyses, in having the transverse

process replaced by tubercles for the rib, in the not dissimilar neural arch being permanently separated from the centrum, while chevron bones are wanting in the tail, the caudal vertebræ elongate towards its end, and the prepelvic ribs have a double articulation with every vertebra.

No mammal has the rib articulated to the centrum by two articular facets; nor have mammals caudal ribs, as in *Ichthyosaurus*; nor are the short sternal bones ever transversely elongated to form median pieces which lap along the sides of sternal ribs.

The resemblance of the ichthyosaurian pectoral girdle to that of monotreme mammals is not close; for in the monotreme the coracoids are divided so as to form a pair of precoracoids which meet mesially, and are overlapped by the interclavicle, while no such division is seen in *Ichthyosaurs*; the scapula is a squamous broadly expanded bone with an acromion, very unlike the narrow elongated bone of *Ichthyosaurus*; the clavicles of the monotreme only extend to the acromion, instead of lapping along the whole anterior margin of the scapula as in *Ichthyosaurus*; and the interclavicle laps behind the clavicle, instead of beneath it as in *Ichthyosaurus*. The clavicle and interclavicle are the only bones which have any close similarity of form in the two types. The combined coracoid and precoracoid of the monotreme would not give the form of the coracoid bone in *Ichthyosaurus*, from which there would be a notable difference in the great thickness of the acetabular part of the bone.

The pelvic girdle is less like that of a mammal. There is a similarity in the ischium being larger than the pubis, in the narrow pubis having a straight anterior border, and in its being (sometimes) ankylosed to the ischium to enclose an obturator foramen. I do not remember any evidence whether the narrow curved iliac bones were inclined forward or backward: they had no osseous union with a sacrum. As a whole, the pelvis is probably least unlike that of the monotreme, omitting from consideration the prepubic bones, to which *Ichthyosaurus* has nothing corresponding.

The humerus has a general resemblance to that of Cetaceans in the shortness, strength, and compression of the bone, in the distal end being formed of the flat inclined articular facets, in the proximal end being hemispherical, and in the flattened underside of the bone being obliquely concave. The differences are, that in Cetacea the outer trochanteroid ridges are suppressed, while those on the inner side are so much developed, after the plan of the

proximal end of the femur in *Chelone*, as to give the Porpoise-humerus a character very unlike *Ichthyosaurus*. The ridges on the humerus of *Ornithorhynchus* may also be compared.

In no mammal is a parallel found to the shortness of the ichthyosaurian ulna and radius, or to the uniform (commonly quadrate) shape of the other bones of the limb or to their arrangement, so that every surface except the exterior surface commonly touches another bone in the adult. Some Ichthyosaurs have a separate olecranon-ossification.

The femur in shortness and strength recalls some Seals; but in arrangement of parts the resemblance is closest to *Ornithorhynchus*, which similarly has lateral trochanters which extend the width of the bone at the proximal end, though in *Ichthyosaurus* they are not divided from the rounded articulation. In *Ichthyosaurus* the bone is shorter, compressed at right angles to the head at the distal end, which does not articulate chiefly with the tibia, but gives an equal flattened facet to both tibia and fibula. No mammal offers any parallel to the other bones of the hind limb, though in Cetacea the limbs are similarly enclosed in a fin-like sheath.

Prof. Owen has thought that since in Cetacea the terminal caudal vertebræ supporting a transverse fin are compressed from above downwards, we may infer that *Ichthyosaurus* had a vertical fin, since the terminal caudal vertebræ are compressed from side to side. But in the human species the caudal vertebræ are compressed from above downward, and in Crocodiles they are compressed from side to side, without in either case carrying a corresponding terminal fin.

## § 2. *The Avian Characters of Ichthyosaurus.*

Many birds, in general form of the head, resemble *Ichthyosaurus* in its different species; but in details the correspondence is not close. Thus, though in both the (usual) backward position of the external nares prolongs the premaxillary bones backward, diverging, along the alveolar border, yet in birds a median ray is prolonged backward between the nares, and overlapping the large nasal bones, so as to nearly hide them, and look from the outside as though it divided them; while in *Ichthyosaurus* there is no such median ray, and the separate premaxillary bones are divided by nasal bones relatively larger than those of Struthious birds. The premaxillary bones usually make more of the palate

in birds than in Ichthyosaurs. The occipital condyle is similarly single, but the exoccipital bones partly contribute to form it, in birds. In both types the base of the sphenoid is expanded, and gives attachment in front to a long slender præ-sphenoid bone.

There is a difficulty in determining the bones of the Ichthyosaurian palate: the large bones which meet the quadrate bones and lap round the sides of the basisphenoid are unlike in form and relations to the style-shaped pterygoids of birds; then there is no certain evidence whether they give attachment to large and more bird-like palatines (usually anchylosing with the pterygoids), or whether the entire bone is pterygoid bone. But in any case there is a difference from birds in the long anterior ends being prolonged between the vomers, and in the existence of a long bone between the maxillaries, which, if the anterior parts of the inner pair of bones are the palatines, would be transverse bones, and which, if the entire bone is the pterygoid, would be palatine bones.

In many birds there is similarly a circle of sclerotic bones to the eye. Among the more striking differences, in birds the orbit is not usually surrounded by a circle of separate bones. The prefrontal and lachrymal are anchylosed together. The quadrate bone is never hidden by other bones, though it is partially covered in some struthious birds; there are no postorbital or supraquadrate bones, and usually no postfrontal. The lower jaw in *Ichthyosaurus*, except the hoof-like articular bone, is made by a number of long splint-like bones overlapping each other laterally, unlike those in the jaw of a bird.

There is nothing like the vertebral column of *Ichthyosaurus* among birds. The chief differences are in the absence of separate cervical and caudal ribs in the bird, in the large sacrum, in the transverse platform-processes to the dorsal vertebræ, in the union of the neural arch in each vertebra with its centrum, in the elongated centrum of the bird (which, however, exceptionally has biconcave articular ends, especially in the tail and back). There is a great difference usually in number of vertebræ, especially as seen in the relative lengths of neck and tail.

The costal ribs of Ichthyosaurs have two heads; but they articulate not with facets (except the upper head in the neck) or concavities, but with tubercles, which are always on the centrum. The median sternal ribs of Ichthyosaurs have in birds become a continuous median ossification or sternum.

The pectoral girdle of birds is not like that of Ichthyosaurs; and the difference is largely due to the development of a sternum in birds. The sternum of a young struthious bird, while its two halves remain separate, has quite the aspect of a pair of potential coracoid bones. And with such a view the interpretation of the keel in carinate birds as the potential interclavicle would be in harmony, since it overlaps the line of union of the two bones as in *Ichthyosaurus*.

The compressed elongated scapula of the bird, enlarging at the articular end, differs from that of *Ichthyosaurus* more in its slender proportion than in its plan, though it has in many water-birds an acromial tubercle for the end of the clavicle, and does not receive that bone along its whole anterior margin.

The clavicle of the bird differs from the typical single clavicle of *Ichthyosaurus* only in wanting connexion with the margin of the scapula and with an interclavicle (unless it is supposed to occur when the clavicle articulates with the sternal keel). The coracoids of birds differ from those of Ichthyosaurs in their elongated form and in not meeting each other mesially.

The pelvis of a bird is entirely unlike that of an Ichthyosaur. In the Emu the pubis and ischium are more slender than in most Ichthyosaurs; but the pubis has not the straight anterior margin of *Ichthyosaurus*, and the ischium has a tubercle towards the proximal end (by which it meets the side of the pubis), which in *Ichthyosaurus* is not developed. The ilium is totally different.

In the limbs of birds there is no structural resemblance, either in the forms of the bones or in their arrangement.

### § 3. *The Crocodilian Characters of Ichthyosaurus.*

The crocodilian head is usually more depressed than in any Ichthyosaur, and, except in the Gavials, has not so pointed a snout, while the surface of the cranial bones is always more or less pitted. The chief changes necessary to convert the crocodile into *Ichthyosaurus* would be an enormous enlargement of the eye, so as to raise it from its nearly flat position to a nearly vertical one. This would draw the maxillary bone up till it was nearly vertical, draw the prefrontal and postfrontal together above the orbit, and allow an enormous median triangular space for the nasal bones to expand in and encroach upon the frontal. The enlarging of the orbits would enlarge the temporal fossæ and extend the squamosals backward. The vacant space in the Croco-

dile-skull behind the orbit and between the postfrontal and malar would need to be covered by two bones—a postorbital (completing the orbit), and a supraquadrate (between the squamosal and quadrato-jugal).

These changes would probably bring the quadrate bone vertical. The parietal and frontal would both have to be double; and the anterior nares would have to be divided and carried backward between the maxillary and nasal bones till they met the lacrymals, prolonging, with them, the premaxillary bones, partly at the expense of the maxillary bones, and partly hiding them by overlap. Then, by adding a foramen parietale between the parietal and frontal bones, so far as the essential external characters went, the head of a crocodile would have become the head of *Ichthyosaurus*. Then, to complete the correspondence on the palate, it would be necessary to connect the quadrate bone made vertical with the hinder angle of the pterygoid, and to separate the pterygoid and palatine bones so as to exhibit the basisphenoid and presphenoid, circumscribe a large pear-shaped palatal vacuity wide behind, and obliterate the maxillo-pterygoid fossæ by pressing the palatine against the transverse bone. The vertical position of the maxillaries draws them apart on the palate, and away from the palatines, so that the premaxillaries are introduced internal to the maxillaries in front; and the vomers are introduced between the premaxillaries and the diverging palatines behind. Thus by opening the crocodilian palate it becomes ichthyosaurian.

The resemblances between the two types are thus seen not to be close; but the differences are chiefly dependent upon the position and condition of the orbits and nares. In both the occipital condyle is single; but in Crocodile it is hemispherical and small, and its upper angles are made by the exoccipital bones. In both the temporal fossa is surrounded by parietal, squamosal, and postfrontal bones. In the orbit the differences are that in *Ichthyosaurus* the frontal bone is entirely excluded, and the postorbital bone becomes ossified. The lower jaw has a general resemblance in both; but the os articulare is longer in Crocodile than in *Ichthyosaurus*. The teeth placed in a groove are in this said to be comparable to the posterior part of the jaw in the Black Alligator.

In the vertebral column there is but little other resemblance than that both have long tails. The chief points in which the Crocodile differs are:—in having the vertebræ much longer and less numerous, furnished with neural arches which unite sutu-

rally, and in the dorsal region give off strong compressed transverse processes to which the ribs are exclusively attached; that the centrum is procœlian, and in the caudal region furnished with chevron bones; that the articulation for the rib in passing from neck to back in Crocodile ascends, while in *Ichthyosaurus* it descends.

The ribs also have little in common; for in *Ichthyosaurus* they are of a generally uniform character, while in Crocodiles there are double-headed  $\perp$ -shaped cervical ribs, double-headed dorsal ribs which never articulate with the centrum, and no caudal ribs at all. There are no median sternal ribs.

The pectoral girdle differs in crocodiles having no clavicles or interclavicle, and by the coracoids articulating with a narrow sternum which extends beyond them anteriorly and posteriorly.

The scapula of the crocodile would have a general similarity of form if its anterior margin were straight instead of being concave; but at the expanded end the surface for the coracoid would have to be in front, and that for the humerus behind; and the coracoids, besides a similar reversal of articular surface, would require immense antero-posterior expansion to change the hour-glass shape of the crocodilian bone into the transversely pedicled ovate shape of the bone in *Ichthyosaurus*.

In the pelvis the ilium is quite dissimilar; and the crocodilian ischium differs in supporting the pubis (?) on a pedicle so as to exclude it from the acetabulum. And thus the pubes are thrust forward, so that they do not meet the ischia in the line of symphysis; and the crocodilian pubis never has the anterior margin straight. The ichthyosaurian ischium never has its proximal end so massive as in the crocodile.

The functional elongation of the limbs in crocodiles in relation to movement on land gives to their several segments characters which make comparison with Ichthyosaurs impossible. In the femur the only resemblances are that the articular ends are compressed, the proximal one rounded and at right angles to the distal end.

#### § 4. *The Chelonian Characters of Ichthyosaurus.*

On the upper surface of the skull the correspondence between the two types is limited to the median bones of that roof of the skull being double, the elongation of the parietal bones in harmony with large temporal fossæ, the vertical position of the orbits,



and an approximation of the prefrontal and postfrontal bones together, so as almost to meet in Chelonians as they do in Ichthyosaurs. Of all that part of the ichthyosaurian skull which is in front of the nares, the Chelonian skull has no representative. If, then, we took such a truncated ichthyosaurian skull and tried to approximate it towards a Tortoise, it would be necessary first to remove the nasal bones entirely. This would expose much of the frontal bones which they cover, and allow the prefrontal bones to be squeezed together to meet mesially and make the upper margin of the nares. A similar compression together of the terminal minute remnants of the premaxillaries would make the lower margin of a single terminal nostril like that of *Testudo*. The foramen parietale must be obliterated, and the supraoccipital developed and prolonged with the adjacent angle of the parietal bones into a strong median occipital crest. The postorbital and supraquadrate bones would be obliterated, and the malar, postfrontal, and quadrato-jugal bones prolonged behind the orbit to meet in a triradiate union. Then, with an inflating auditory excavation of the quadrate and squamosal bones, to outward view the upper part of the Ichthyosaur's skull would have become Chelonian. In the palate there is a primary difficulty with the homology of the bones, because on the ichthyosaurian palate there are small vacuities under the place of the external nares, which might be regarded as posterior nares, either potential or actual; and they are surrounded chiefly by two bones, the vomer internally and what might be the palatine externally, the premaxillary sometimes entering in front. I adopted another interpretation to explain the relation of the palate to that of Crocodiles; this interpretation would be as necessary to harmonize it with that of Chelonians. Then, to complete the resemblance to Chelonians, it would be necessary to unite the two vomers into a single median vomer, into which the pterygoids should not penetrate posteriorly; and then, by extending the pterygoid bones internally till they met mesially so as to hide the presphenoid and cover the palatal vacuity, the change would be perfect but for the want of teeth.

Thus the cranial resemblances of Chelonians to Ichthyosaurs are so slight that they are scarcely of any value. The back of the head is as unlike as the other parts: there the exoccipitals contribute equally with the basioccipital to the condyle, and in Testudines the opisthotic meets the squamosal bone only,

while in *Chelone* it meets the quadrate ; in *Ichthyosaurus* it meets the quadrate by curving under the squamosal. The splint character is wanting from the Chelonian lower jaw ; it has no keel behind the articulation ; and the dentary bone is single.

The vertebral column is very dissimilar, there not being a single character in common.

The ribs, limited to the dorsal region in Chelonians, would seem to be as dissimilar as the vertebræ, unless, indeed, the seemingly double rib of the Ichthyosaur, grooved throughout its length, be an epipleural growth repeating the costal rib upon itself throughout its length, as is the case with Chelonians.

The pectoral girdle is altogether dissimilar, being formed in Chelonians of long spathulate coracoids which do not meet each other mesially, and of rod-like scapulæ which give off a long rod-like precoracoid process.

The pelvic arches are only similar in the form of the ilium, which in both is a short curved bone rather compressed. The two trochanters to the head of the femur of *Chelydra*, though not so well developed and not opposite to each other, are homologous with those of the head of the femur in *Ichthyosaurus*. Beyond this there is in the limbs no character in common worth dwelling on.

#### § 5. *The Lacertian Characters of Ichthyosaurus.*

All living reptiles are with difficulty compared with *Ichthyosaurus*, owing to the backward and lateral position of its nares. *Polychrus anomalus* has the nares far back ; and in the Nilotic Monitor they are not near the tip of the snout ; but in no lizard do the premaxillaries form the lateral margins of the palate, as in *Ichthyosaurus* ; and, contrary to the rule with Ichthyosaurs, they are single and prolonged back mesially between the nares, except when, as in *Monitor*, the nares reach so far back that they are divided by the nasal as they are in *Ichthyosaurus* ; only in *Monitor* the nasal bone is single and narrow. Lizards differ in having the whole lateral alveolar border made by the maxillary bones margined by a conspicuous row of foramina.

The orbit of *Ichthyosaurus* is circumscribed by bones as in many lizards, such as *Iguana*, *Uromastix*, *Stellio*, *Scincus*, *Draco*, &c. ; but the bones which enter into its outer margin are not the same. At the base in both is the long curved malar, and in front of that in lizards a small, and in Ichthyosaurs a large lachrymal bone,

and above that a premaxillary ; and both agree in excluding the maxillary bone from the orbit. But lizards appear almost invariably, and like Chelonians, to admit a small portion of the frontal into the upper orbital margin between the prefrontal and postfrontal, while in *Ichthyosaurs* these bones meet. In *Iguana* and many lizards, behind the orbit, completing it, is a bone which connects the postfrontal above and the malar below with the quadrato-jugal behind, and so has the relations of the postorbital in *Ichthyosaurus*—though, from the liberation of the quadrate bone in lizards, the postfrontal and squamosal have lost their function, and are of smaller size, and the postorbital and quadrato-jugal are of different form and relations. Lizards have no supraquadrate, often have the frontal single, always have the parietal single and diverging backward in a V-shape ; while in *Ichthyosaurus* the backward divergence is less, and almost entirely made by the squamosal bones, which recurve forward round the temporal fossa to meet the postfrontals above the supraquadrate and postorbital bones—an arrangement not seen in lizards.

The foramen parietale is, in lizards, only a vertical puncture in the parietal, or between the parietal and frontal bones ; in *Ichthyosaurus* it is an oblique canal. In *Ichthyosaurus* the quadrate bone is seen from behind to be supported by the squamosal, opisthotic, and pterygoid ; in lizards its upper end unites with the transverse bar of the exoccipital, and its lower end with the slender backward prolongation of the pterygoid.

The palate in both types is open mesially, especially in such a lizard as *Monitor*, where the presphenoid is seen extending down a similar palatal vacuity. Lizards, however, have pedicels to the basisphenoid which meet the pterygoid bones ; while in *Ichthyosaurus* the pterygoids are more expanded, and lap round the sides of the basisphenoid. In front of the long pterygoids are short palatine bones in *Monitor* ; and between the pterygoid, palatine, and maxillary are small transverse bones. In *Ichthyosaurus* both of these bones are longer than the pterygoid (supposing, as was done in the comparison with crocodiles, that the palatine and pterygoid bones are usually anchylosed). The vomers of *Monitor* are long slender bones, as in *Ichthyosaurus* ; but the palatine bones are not similarly prolonged between them, nor are the premaxillaries external to them.

The occipital condyle of lizards is largely made by the exoccipital bones. The teeth are never in a groove, and often differ in

character in passing backward, unlike *Ichthyosaurus*. The lower jaw of lizards has a strong, vertically developed, coronoid bone, not seen in Ichthyosaurs; and the bones have not the usual splint-like overlapping. The dentary forms half of the jaw.

In number of vertebræ and in length of tail lizards rival Ichthyosaurs. And in the *Hatteria* the centrum is biconcave; but in all lizards it is greatly longer, and in most lizards the centrum is procœlous, and in certain tail-vertebræ ossified in two parts, anterior and posterior. In *Monitor* the neural spine is vertical and quadrate, but not so long as in *Ichthyosaurus*, except in the tail; and there, relatively to the centrum, it is not so wide. The neural arch is ankylosed to the centrum in lizards, and separate in Ichthyosaurs. In the lizards there are often both transverse processes and chevron bones in the tail, neither occurring in *Ichthyosaurus*—though the transverse processes of reptilian caudal vertebræ have the aspect of caudal ribs, like those of Ichthyosaurs, ankylosed to the centrum. The ribs of lizards are supported on a strong short pedicle, which appears to be contributed to by both neural arch and centrum, and is at the anterior end of the vertebra, well below the præzygapophysis; while in *Ichthyosaurus* the articular thoracic tubercles are small, double, and raised but little above the surface of the centrum.

The costal ribs of lizards are strong, less compressed from front to back, want the groove which runs along the middle of an Ichthyosaur's rib, and have the proximal articulation massive and single, instead of compressed and terminating in two articular tubercles.

The sternal and median ribs, unlike those of *Ichthyosaurus*, are modified in relation to a sternum, are not well ossified, and do not unite with the other costal elements by overlap.

In the pectoral girdle there is the fundamental difference that lizards have a sternum, but in spite of it the coracoids, by a wide median expansion, almost meet mesially. Their approximations, however, are (typically) deeply emarginate; and so the whole bone becomes dissimilar in form to the coracoid of *Ichthyosaurus*, though in *Polychrus*, for example, the coracoid is small and not unlike that of *Ichthyosaurus*. Here, too, the scapula is more ichthyosaurian than usual with lizards, some, like *Monitor*, having the bone united with the coracoid throughout its length, others, like *Iguana* and *Skink*, giving off a strong acromion process from the anterior margin; but in *Polychrus*, *Draco*, &c. the bone is com-

pressed, with subparallel sides, moderately elongated, and expanded a little at the articular end, while it similarly carries the clavicle along its anterior margin. The clavicle, however, is double, as in some Ichthyosaurs, but otherwise not dissimilar, except that in lizards its length is very variable, and sometimes, as in *Scincus* and *Iguana*, it is compressed and widens from front to back. The interclavicle of lizards is usually T-shaped (though + -shaped in *Scincus*), and similar to that of *Ichthyosaurus*, except that most lizards carry the cross bar behind the clavicles, though *Polychrus* carries it below them as in *Ichthyosaurus*. The median bar, however, in lizards laps down the outside of the sternum, while in *Ichthyosaurus* it binds the coracoids together.

The pelvis is dissimilar; for in lizards the ischium has a posterior tuberosity, and the pubis an anterior tuberosity, the two bones do not meet at the symphysis, while the ilium extends both in front of and behind the acetabulum.

The limbs offer no community of structure. The proximal end of the femur in lizards has but one trochanter; and that is in a line at right angles to the ovate compression of the head.

#### § 6. *The Chameleon-Characters of Ichthyosaurus.*

The chameleon-skull offers no resemblance of importance to *Ichthyosaurus* beyond such as are seen in the skulls of lizards, except that the anterior nares are better defined and lateral, that the orbit is relatively larger and has an osseous floor. The sutures, however, are less well defined.

The coracoid, but that it wants the anterior emargination, is like that of *Ichthyosaurus*; and the scapula, but that it is relatively too long and has the anterior border concave, approximates to the ichthyosaurian type. The chameleon pectoral arch differs in wanting a clavicle and interclavicle, and in possessing a sternum. The pelvis is very like that of *Ichthyosaurus*, except that the ilium is longer, and that the pubis and ischium do not meet at the symphysis. The pubis has the anterior margin straight, and differs chiefly in being perforated by the obturator nerve. The ischium differs chiefly in having a relatively greater antero-posterior extent along the symphysis.

#### § 7. *The Rhynchocephalian Characters of Ichthyosaurus.*

*Hatteria* agrees with *Ichthyosaurus* in having the median bones which roof-in the skull all double; it has a large foramen parie-

tale, but entirely within the parietal bones. The temporal fossæ are large in both types. In *Hatteria* the postfrontal is divided so as to form a bone like that named postorbital in Lizards; but in some Ichthyosaurs the postfrontal appears to be divided, as in lizards; and if so, the temporal fossæ are circumscribed by the same bones in *Hatteria* and *Ichthyosaurus*, and the bones are similarly placed. The nasals of *Hatteria* are relatively small, and do not extend over the frontals and between the orbits, nor do the postfrontal and prefrontal bones meet above the orbit, as in *Ichthyosaurus*. The quadrato-jugal, supraquadrate, and probably the postorbital bones are wanting from the skull of *Hatteria*, as well as the transverse bone. In *Hatteria* the base of the orbit is made by a large turtle-like maxillary, which almost excludes the malar bone. In *Ichthyosaurus* the malar bone forms the base of the orbit, and entirely excludes the maxillary. *Hatteria* possesses an interorbital septum, which does not exist in *Ichthyosaurus*. The quadrate bone is very unlike that of *Ichthyosaurus* in being perforated from back to front, and in sending a long process forward and inward to lap in front of the pterygoid; and it is jammed in the skull more firmly.

The palate is not so open as in *Ichthyosaurus*. And it is necessary to use the "chelonian" interpretation of *Ichthyosaurus* to harmonize the bones. The pterygoids of Ichthyosaur would need not to be prolonged anteriorly between the vomers, but only to meet them and allow the vomers to meet mesially. And the premaxillary would not need to be prolonged so far back between the maxillary and vomer to give the ichthyosaurian palate the essential peculiarities of *Hatteria*, except that in *Ichthyosaurus* the palatine does not carry teeth. Of course the prenasal part of the skull does not admit of comparison, any more than do the teeth.

The vertebræ, though shorter from back to front than in lizards, have the centrum much longer than in *Ichthyosaurus*; the neural arches are stronger than in *Ichthyosaurus*, and differ in being anchylosed to the centrum. The caudal vertebræ are ossified in two parts in *Hatteria*, so that the suture divides the two cups; but of this *Ichthyosaurus* shows no trace. There are median abdominal ribs; but the costal ribs of *Hatteria* have expanded single heads. The apparatus of infracostal ribs seems capable of being moved away with equal entirety in both groups, owing to the union of some of the elements by overlap. The

scapula and coracoid are not dissimilar; but in *Hatteria* the coracoid has no anterior emargination, and the anterior margin of the scapula is not straight. The clavicles do not meet mesially, but unite suturally (as in some Ichthyosaurs) with a crescentic transverse bar of the interclavicle, which is closely united with a large pentagonal sternum and so far is unlike that of *Ichthyosaurus*; a large cartilage, however, extends the coracoid to meet both its vertical and transverse parts.

The pelvis is dissimilar; and the limbs are not comparable.

#### § 8. *The Ophidian Characters of Ichthyosaurus.*

It were difficult to find any character of structural importance in common between these types. Prefrontal and postfrontal with an anterior division of the postfrontal, called the supraorbital bone, combine to exclude the frontal from the orbit in *Python*; but the nasals are small and the parietals single and long.

Nor is the correspondence close on the palate; for, besides all the bones being loose in serpents, there is a transverse bone, the pterygoids and palatines both carry teeth, and, though the palatines are separated in front by the vomers, the pterygoids are not prolonged forward between the palatine bones and vomers as they are in *Ichthyosaurus*. The pterygoids, as in lizards, meet tubercles of the basisphenoid, and then diverge outward and backward to the quadrate, and do not lap round the basisphenoid as in *Ichthyosaurus*. The lower jaw, too, is quite dissimilar, its anterior half being made up by the dentary bone.

In number of vertebræ serpents far surpass Ichthyosaurs; but the vertebræ have no character in common, serpents having the centrum much longer, procelous, with one long tubercle for the rib, with the neural arch ankylosed to the centrum, a short neural spine, and a zygosphenæ; in the tail there are transverse processes and hypapophyses,—all of which characters distinguish the vertebræ of serpents from those of Ichthyosaurs.

#### § 9. *The Urodelan Characters of Ichthyosaurus.*

The urodelan skull in the Hell-bender, Salamander, or Triton is not like that of *Ichthyosaurus*; for the palate is closed by a bone (parasphenoid) which divides the pterygoids and meets the vomers, which carry teeth. In *Ichthyosaurus* this bone does not exist. Then in these animals the orbit is confluent with the temporal fossa; and the space is not circumscribed, there being

no malar, quadrato-jugal, supraquadrata, or postorbital bones. There are no palatal nares. There is no basioccipital; and the articulation with the vertebral column is formed by the exoccipital bones. And the quadrate is embraced exclusively by the pterygoid and squamosal. The anterior nares appear to be surrounded by the premaxillary, maxillary, small nasals and large frontals. The frontal bones, however, may as probably be the prefrontal, in which case it would be intelligible that the bones external to them should unite posteriorly with the parietals, being postfrontal bones. The lower jaw is almost entirely made of the dentary bone with an articular element behind, and a long angular or coronoid or opercular element on the inside.

The vertebral column has nothing in common, except that in both the centrum is biconcave. But in the Amphibians the centrum is long, the neural arch is depressed, the zygapophyses are nearly horizontal, and there is no neural spine. There is no atlas; and the axis has an odontoid process, the odontoid process really being the basioccipital bone. There are transverse processes given off from the combined neural arch and centrum; they are sometimes grooved, so as to have two articular heads for a rib; they are always directed backward, and are often long. These transverse processes are continued part of the way down the tail. The caudal vertebræ have chevron bones ankylosed to the underside of the centrum. In all these characters Amphibians differ from Ichthyosaurs.

The ribs are altogether dissimilar, except that they have two articular heads; for they are always very short, and do not contribute to enclose the viscera, but are directed horizontally outward and backward.

The pelvis is not like, there being no pubis ossified, and the ischium being a greatly expanded plate in no respect like the ischium of *Ichthyosaurus*.

The pectoral arch consists of a combined scapula and coracoid; but the bones do not meet mesially. The scapular portion is made unlike the scapula of *Ichthyosaurus* by its great width at the line of union with the coracoid, due to forward outgrowth, which makes the anterior margin deeply emarginate. The coracoid portion (which is not distinct) has neither the anterior nor posterior emarginations which characterize the coracoid of *Ichthyosaurus*.

The limbs are totally dissimilar.



§ 10. *The Piscine Characters of Ichthyosaurus.*

In the general form of the head, *Xiphias* resembles *Ichthyosaurus*. The premaxillaries in both are elongated, terminate the long snout, and form the alveolar border, which in *Xiphias* does not carry teeth; they are followed behind in both by a pair of greatly elongated triangular nasals, which widen behind.

The frontals and parietals of *Xiphias* are both large; the prefrontal is covered by nasal and frontal; and the prefrontal and postfrontal do not meet to exclude the frontal from the orbit. Neither orbits nor temporal fossæ are circumscribed; and there is no foramen parietale.

The basioccipital is conically cupped, and carries the exoccipitals, which meet below the neural canal, and furnish concave facets which contribute to the articulation with the vertebral column, which is thus very unlike that of *Ichthyosaurus*. The exoccipitals also enclose the neural arch above. On the palate, too, there is nothing in common, the bones being single and closing the palate mesially. In very few fishes is there a convex basioccipital; among such is *Fistularia*.

The vertebral column of fishes, though as variable as the skull, never approximates in any genus to that of *Ichthyosaurus*, except in the biconcavity and sometimes in the shortness of the centrum. The essential difference from a fish is in having the ribs articulated to the centrum by two tubercles.

The arches and limbs do not correspond at all.

§ 11. *The Plesiosaurian Characters of Ichthyosaurus.*

In *Plesiosaurus* the snout is never so long as in *Ichthyosaurus*, or so pointed; but the nostril is near the eye; and nostril, orbit, and temporal fossa are all surrounded with bone, though relatively to *Ichthyosaurus* the temporal fossa is large and the orbit small. The premaxillary is like that of *Ichthyosaurus*, only much smaller; and the nasals, which extend between the nostrils in front and behind, are narrow and small relatively to those of *Ichthyosaurus*. The frontal appears in *Plesiosaurus* to enter into the upper margin of the orbit; and the postfrontal appears to meet the malar and close the orbit behind; so that there are no post-orbital or supraquadrate bones. And the outer margin of the temporal fossa is made by the malar meeting the squamosal; whether there is a quadrato-jugal I find no satisfactory evidence.

The palate differs in being closed mesially. The vomers appear to extend far forward between the maxillary bones. The median bones behind the vomers consist of palatine and pterygoid with a transverse bone external to these. In both the occipital condyle is single; but in Plesiosaurs the exoccipital bones usually enter into it. In both there is a foramen parietale. In Plesiosaurs the quadrate bone is directed backward, as in crocodiles and Teleosaurs, and is more intimately united to the skull than in Ichthyosaurs. The teeth differ in no essential, except that in Plesiosaurs the fang is cylindrical and the crown has a tendency to curve backward.

The pectoral girdle has much in common in plan in the two types, though the forms of the bones differ greatly. In order to convert the *Ichthyosaurus* into *Plesiosaurus*, it would be necessary to amalgamate the clavicle and interclavicle into one bone, and then contract the three arms till the scapulæ were drawn almost together in front, and the median ray only just met the coracoid behind. Sometimes the interclavicle entirely disappears; and then the scapulæ grow together mesially to replace it, and meet the coracoid mesially. The coracoid bones would require to be relatively enlarged and to be prolonged further backward.

The pelvis of *Plesiosaurus* in none of its elements closely resembles that of *Ichthyosaurus*. The ilium differs in being straighter, more massively expanded at the femoral end, and usually more compressed at the vertebral end. The ischium differs in being directed backward, and in being usually more extended along the symphyseal line. The pubis is entirely different, being in *Plesiosaurus* subreniform.

The vertebral column has nothing in common in the two groups, except the biconcavity of the centrum. In *Plesiosaurus* the centrum is more elongated from back to front, and the neural arch is usually ankylosed to the centrum of the cervical vertebræ.

The femur differs in the relatively larger size of the proximal end, in wanting an inner trochanter at the proximal end, in the greater elongation of the shaft, and in the greater expansion of the distal end.

In *Plesiosaurus* there is some similarity in the ulna and radius, and carpus and tarsus, to those regions in *Ichthyosaurus*; and it is only by minute comparison that the bones can always be distinguished.

§ 12. *The Dinosaurian Affinities of Ichthyosaurus.*

The *Scelidosaurus* has the median roof-bones of the skull all double; the nasal bones are large and elongated, but they do not extend so far back as in *Ichthyosaurus*, and so the frontal bones occupy a much larger area of the skull. The frontal bone similarly does not enter into the orbit; but in *Scelidosaurus* the superior border is made by an anterior division of the postfrontal, which Prof. Owen names the superorbital bone. The orbits are vertical in both, and the temporal fossæ are horizontal. The bone behind the orbit in *Ichthyosaurs* is named postorbital; and as the sequence of the bones is the same in both, an advocate for a uniform nomenclature might propose to name the dinosaurian postfrontal postorbital, and the superorbital postfrontal. Then the bones surrounding the orbit would be the same in both. In both the eye is defended with sclerotic plates. But there is no supra-quadrato in the Dinosaur, and no clear evidence of a quadrato-jugal, while the quadrato would differ from that of *Ichthyosaurus* in its slender form and in the long inner process which laps along the pterygoid.

The palate of a Dinosaur is not very like that of a lizard, the pterygoid bones being more expanded; the pterygoid bones in *Scelidosaurus* are very unlike those of *Ichthyosaurus*.

The teeth of Dinosaurs are chiefly in the maxillary bone; and these teeth are always serrated. In *Hypsilophodon* the pre-maxillary teeth are very different from the maxillary teeth, and so are unlike those of *Ichthyosaurus*, although the crowns are conical.

The vertebral column has nothing in common, the dinosaurian centrum always being elongated as in Plesiosaurs, never deeply cupped, without tubercles for ribs on the dorsal vertebræ, always furnished with a large neural arch. In the caudal region there are chevron bones and transverse processes.

The pectoral girdle would appear to differ by the Dinosaurs being devoid of clavicle and interclavicle, and showing traces of a partly (?) osseous sternum. But of the other bones, the scapula and coracoid have considerable resemblance of form. The coracoid bone, for instance, usually referred to *Iguanodon* cannot be regarded as having any character to distinguish it from *Ichthyosaurus*; and the scapula differs chiefly in its relatively greater length, and the development of an acromial tubercle or prearticular prolongation on the anterior margin. The pelvic arches

have little in common—the ilium being greatly expanded in Dinosaurs, while the pubis and ischium are more elongated than in Ichthyosaurs, and less expanded at the symphyseal end.

The proportions of the limbs are reversed, the hind limbs of Dinosaurs being the larger. In the bones of the limbs there is no correspondence of form or plan.

### § 13. *The Dicynodont Characters of Ichthyosaurus.*

In *Dicynodon* the premaxillary and the parietal bones are single, and the foramen parietale perforates the parietal only, so far being unlike *Ichthyosaurus*. But the nares and orbits are lateral and circumscribed, though the orbits are relatively smaller, and the nares are, from the shortness of the snout, not so far back in the skull. The temporal fossæ are similarly circumscribed; and the parietals and squamosals similarly diverge behind, though often with a more marked V-shape in Dicynodonts than in *Ichthyosaurus*. The peculiar bones of the Ichthyosaur's skull are wanting; and the quadrate bone is a naked pedicle firmly united to the solid vertical back part of the skull. The dicynodont occipital condyle consists of three equal parts contributed by the exoccipital and basioccipital bones. The palate and teeth are both unlike those of *Ichthyosaurus*.

The vertebræ are often not dissimilar to those of *Ichthyosaurus* in the deep cupping of the centrum; but the centrum is longer, the neural arch is ankylosed to it, and the attachment for the ribs is altogether different in Dicynodonts.

The pectoral and pelvic arches are altogether dissimilar; and the limbs, except in the great expansion of the humerus at its proximal and distal ends, have nothing in common.

### § 14. *The Labyrinthodont Characters of Ichthyosaurus.*

Labyrinthodonts agree with Ichthyosaurs in having the median roof-bones of the skull all double, in having the orbits circumscribed with bones, with a postorbital bone behind, and a supraquadrate bone behind that, between the squamosal and quadrato-jugal. But they differ in having the temporal fossæ entirely roofed over, in the foramen parietale perforating the middle of the parietal bones, in the orbits being small, in the great elongation of the principal frontal bones, in the forward position of the nares (usually nearer to the end of the jaw than to the orbits), and in the short premaxillary bones (which sometimes

have a tendency to unite mesially). The palate differs in having its anterior part largely made by the vomerine bones, which meet the potential presphenoid style behind.

The premaxillary and maxillary bones usually carry a continuous series of teeth smaller than those of *Ichthyosaurus*, while there is an inner series of teeth (on the vomers and palatine bones) of which some are larger than those of *Ichthyosaurus*. The arrangement of palate-bones is very unlike the ichthyosaurian. The substance of the teeth seen in transverse section is much more folded than in *Ichthyosaurus*. In *Mastodonsaurus*, according to Von Meyer, the presphenoid, basisphenoid, and occipital bones are all differentiated, thus approximating to *Ichthyosaurus*, though the articulation with the skull is made by two condyles. The surface of the skull usually differs in being sculptured.

The centrum of the vertebra is similar in the two groups, being very short and biconcave; but the neural arch is more like that of a crocodile than that of *Ichthyosaurus* in supporting the ribs on transverse processes. The ribs are similar to those of *Ichthyosaurus* in their length, flattened character, and the double head by which they articulate with the vertebra.

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## PART II.

### THE RESEMBLANCES OF PLESIOSAURIAN BONES TO THE BONES OF OTHER ANIMALS.

#### § 1. *The Mammalian Characters of Plesiosaurus.*

The sutures are not all well seen in skulls of *Plesiosaurus*; but enough is manifest to show that, in the small size of the parietal region, the large temporal fossa, and the considerable development of premaxillary, maxillary, and nasal bones in front of the anterior nares, the upper surface of the skull differs in aspect from the mammalian type. If the orbits are circumscribed by bones as they are in Ruminants and many other mammals, there is a difference, owing to the frontal bone being excluded, and its place taken by two bones which Prof. Owen names superorbital and postfrontal, but which it would be more consonant with simple naming to call respectively postfrontal and postorbital. The lachrymal bone does not similarly enter into the anterior nares in mammals, though in certain Ruminants there is so

near an approximation to such an arrangement as to show that that condition is quite consistent with the mammal plan. The squamosal is extended outward to cover the quadrate; and so all the outer and backward part of the skull is modified on a plan unlike that of the mammal.

The occipital condyle would appear sometimes to consist only of the basioccipital bone, though in all the specimens in the Woodwardian Museum at Cambridge the exoccipital bones also contribute to it.

The teeth are all in sockets, as in adult Porpoises; about half appear to be in the premaxillary, and half in the maxillary bone. I have seen no evidence of their replacement by successional teeth in *Plesiosaurus*. The closed flat palate, which seems to have two perforations behind for the posterior nares, between the palatine and pterygoid bones, and two perforations external to these, margined outwardly by the transverse bones, finds a general parallel in the Porpoises, though the posterior nares in those animals are not ovoid perforations, and the external foramina have no existence.

The vertebræ have a mammalian aspect. The neck-vertebræ are shortened in *Pliosaurus*, as in Balænidæ and Elephants; but in most Plesiosaurs the centrum slightly elongates in the neck, as in many land mammals, though the vertebræ differ remarkably in number, sometimes counting as many as forty-five and never so few as seven. The atlas and axis are usually ankylosed together; and the cervical vertebræ all carry ribs, some of which sometimes have a divided articular head, and all of which articulate with the centrum: in these characters the vertebræ differ from mammals'. The dorsal vertebræ have much the proportion and characters seen in Porpoises, except that the epiphyses are not separable from the centrum, that the neural arch is often separable from the centrum, that the centrum is usually somewhat cupped, that the neural canal is smaller, and the transverse process rounder, longer, and stronger, and given off from the neural arch throughout the whole of the dorsal region. But in the cardinal character of having the ribs attached by single heads to transverse processes of the neural arch, a number of dorsal vertebræ of Porpoises offer a close resemblance to those of *Plesiosaurus*. And when only the centrum is preserved, it would often be impossible to distinguish between the Cetacean and the Plesiosaur. The neural arch in its general features is very similar in the two. In neither group is there

a sacrum. The earlier caudal vertebræ of both have transverse processes jutting horizontally from the side of the centrum, and chevron bones between the centrams beneath. But in Cetacea the transverse processes on the centrum are common to the later dorsal vertebræ, and the neural arch and the chevron bones do not persist to the end of the tail, and the later caudal vertebræ of Cetaceans become singularly modified in form. As in Porpoises, the dorsal centrum is usually rather longer than the early caudal centrum. The dorsal ribs are similar to those of Cetaceans; but the sternal ribs of a Plesiosaur are unlike those of any mammal.

The pectoral girdle of *Plesiosaurus* has nothing in common with that of Cetaceans or any mammal beyond a distant resemblance to that of the Monotremes.

The humerus of *Phocæna* differs from that of *Plesiosaurus* chiefly in its shortness and the less constriction of the bone below the proximal articulation. And the position of the limb on the body appears to have been different; for in Cetaceans the proximal trochanter is anterior, while in *Plesiosaurus* it appears to be exterior. The points of resemblance are in the proximal and distal ends being in the same plane, in the side-to-side compression of the distal end, which similarly has two flat articular surfaces which meet at an angle, in the proximal end terminating in a hemispherical articulation on one side of the bone and a large trochanter on the other, though they seem to be on opposite sides.

The ulna and radius are relatively to the humerus much longer than in *Plesiosaurus*. The radius is a compressed bone with flattened articular ends in both groups; but the Porpoise differs in having the distal end the wider—while in Plesiosaurs the proximal end is the wider when the ends differ in width, and the anterior and posterior margins of the bone are both concave. The ulna differs in being much wider and usually reniform in Plesiosaurs, so that the posterior margin is convex and the anterior concave, while in Cetaceans the bone is long and narrow, concave behind and usually straight in front: it has a small olecranon process. When the olecranon is developed in Plesiosaurs, it always persists as a distinct ossification.

The carpal bones are so similar in the two groups that they cannot be distinguished from each other. In both they are flat, compressed, subhexagonal, or irregularly ovate ossicles. The

phalanges are so similar that it would not be possible to distinguish between them. They are compressed or rounded hourglass-shaped bones with flat or moderately convex articular ends which often show numerous perforations for blood-vessels, around which the bone is slightly elevated. The digits on the radial side have most phalanges. There may be as few as three digits.

### § 2. *The Avian Characters of Plesiosaurus.*

The backward position and division of the anterior nares in birds, and the consequent extension of the premaxillary bones and backward position of the maxillary bones, accords well with the condition of the prenasal part of the skull in Plesiosaurs. In them the orbits are circumscribed by bones, being bordered below by the malar; they are placed much further forward, more towards the middle of the skull, than in birds; and thus there come to be large circumscribed temporal fossæ behind the orbits, to which there is nothing similar in birds. The eyes are more horizontal than in birds; and some Plesiosaurs, like some birds, have a sclerotic circle of bones. Unlike birds, the quadrate bone is firmly fixed in the skull, and covered, as in some struthious birds, by the squamosal on the outside, which latter bone accordingly does not enter into the brain-case. The cerebral part of the skull is of altogether different form. The occipital articulation is similar, being in both types contributed to by the exoccipital bones.

The palate of struthious birds would be very similar to that of *Plesiosaurus* if the palate were closed mesially and the posterior nares carried through the infraorbital foramina, the nares closed by the growing together of palatine and maxillary; and it would require that the pterygoid bones should be expanded inward and backward, so as to meet behind the nares and cover the region of the basisphenoid, carrying the quadrate bones backward with them. The lower jaw in both is composite and moderately prolonged behind the concave articular groove for the distal end of the quadrate bone.

The vertebral column of Plesiosaurs only resembles that of birds in the large number of vertebræ included in the neck. The centrum differs in having the articular surfaces flat or concave in Plesiosaurs. In birds the atlas and axis are not ankylosed, the cervical vertebræ have no separate ribs, and the neural spine is suppressed, while the vertebral artery is often carried through a ring on the side of the centrum in birds as it is in some



mammals; and no such condition is seen in *Plesiosaurus*. In the dorsal region of birds there is a quadrate neural spine similar to that of Plesiosaurs, only shorter, and transverse processes to the neural arch, which are horizontal laminæ and not sub-cylindrical processes; the ribs in birds are articulated to the side of the centrum on a concave facet, and only touch the underside of the transverse process with the posterior tubercle, while in *Plesiosaurus* the rib is exclusively articulated with the transverse process. The dorsal centrum in many birds has a prominent hypapophysis similar to that of serpents; but nothing of the kind is seen in *Plesiosaurus*. Plesiosaurs have no sacrum; and if in birds the postfemoral vertebræ were put into the tail, that region would be relatively as long as in Plesiosaurs. Plesiosaurs want the terminal caudal style of birds; but the ordinary caudal vertebræ of water-birds are not dissimilar to vertebræ of *Plesiosaurus*, except in the massive or bifid neural spine; and the length and form of the centrum, as well as the absence of chevron bones, make the tail-vertebræ of such birds as the Penguin or the Swan more like the neck- than the tail-vertebræ of *Plesiosaurus*. The caudal vertebræ of the Gannet only differ in size from vertebræ of Plesiosaurs. The dorsal ribs of birds are always more compressed than those of Plesiosaurs, and usually differ in having an epipleuron ankylosed to the middle of the posterior margin of several.

The pectoral and pelvic arches have nothing in common. The difference in the pelvic region is presumably largely due to the extension of the ilium along the whole length of the sacrum in birds, while in Plesiosaurs it is a short conically tapering rod which only meets one vertebra. The difference of the pectoral arch is presumably largely due to the great development of the sternum in place of the system of abdominal ribs. If the scapulæ were to be drawn forward to meet in front of the coracoid bones, the coracoids would themselves be drawn together; and it is not improbable that with such a plesiosaurian modification the muscular attachments would move forward, and the sternum of a bird would lose its continuous osseous character and large size.

Neither humerus nor femur has much in common with *Plesiosaurus*. If the shaft of the humerus is compressed in the Penguin, its distal end is not expanded, and its proximal articulation is expanded too much. In the femur, if the hemispherical head is directed inward, the trochanter external to it is too wide, while the distal end is very dissimilar.

The other bones of the extremities in *Plesiosaurus* have no avian characters.

§ 3. *The Crocodilian Characters of Plesiosaurus.*

In outline and in the depressed character, the skulls of typical crocodiles and Plesiosaurs are similar. The nares, however, in Plesiosaurs are far back on the skull, and only parted from the orbit by the lachrymal bones, while in crocodiles they are single and terminal.

The orbits are not dissimilar in character, but in Plesiosaurs they are in the middle of the skull, while in crocodiles they are in the hinder third. The temporal fossæ are much larger than the orbits in *Plesiosaurus*, while in crocodiles they are smaller. These differences in the positions of organs and regions of the skull necessitate proportionate differences in the length and form of the cranial bones. But in crocodiles the postfrontal is not usually divided so as to exclude the frontal from the orbit; and in Plesiosaurs the postfrontal is divided from the squamosal by the malar and quadrato-jugal, and thus the temporal fossa is enlarged. The quadrate bone is similar in form, similarly placed in the skull, except that in Plesiosaurs the pterygoid bone meets it on the inner side; and usually it is similarly directed backward. The occipital condyle is similarly formed in the two groups; and the occipital bones are not dissimilar. The palate is similarly closed, except that in Plesiosaurs the posterior nares are not carried so far back, being surrounded by the palatine, transverse, and pterygoid bones, and that the transverse bones are more anterior, and larger, and close the palatine foramina in front. The teeth are exceedingly similar, and are similarly placed in sockets, in all crocodiles except the Black Alligator. The lower jaw appears to be similar in the proportions taken by the dentary, angular, and opercular bones, in the form of the concave articulation, and in the extent of the postarticular keel; but in Plesiosaurs its side is not perforated posteriorly. The cranial bones of *Plesiosaurus*, though not always smooth, are never pitted as in crocodiles.

In no known *Plesiosaurus* does the tail include so large a proportion of vertebræ, or the neck so few as in crocodiles. In Plesiosaurs the centrum is rarely, if ever, so long as in crocodiles; and the articular surfaces are never procœlous, but flat or slightly concave at both ends. The neural arch is similar, except that, like the centrum, it is longer from front to back than in Plesio-

saur; the zygapophyses are more projecting; and the transverse process of the dorsal vertebræ is lamellar and not cylindrical. The caudal vertebræ, besides differing from *Plesiosaurus* in their length, differ in the lengths of the chevron bones, which are not attached each between two vertebræ in crocodiles, but to the basal hinder articular margin of its own vertebra. The short cervical vertebræ of Plesiosaurs have a hatchet or J-shape, similar to that seen in crocodiles; and the articular head is sometimes divided to articulate with two facets on the centrum, but never so deeply divided as in the crocodile, where the upper head articulates with a tubercle on the neural arch, while the lower head remains on the centrum, in all the pectoral vertebræ and all the cervicals after the first two.

The dorsal ribs differ from those of *Plesiosaurus* in their compression from above downward, and in the articular end uniting with the transverse process by two heads.

The pectoral girdle is not similar; for in the crocodile the coracoids are divided by the sternum, and they have but little antero-posterior extension, corresponding only with the thick anterior part of the coracoid in *Plesiosaurus*, and the scapulæ are directed towards the back instead of converging forward in the same plane with the coracoids. Nor are the pelvic girdles similar. For the ilium of the crocodile has a vertical expansion very unlike the subcylindrical tapering form seen in Plesiosaurs. The backward direction and symphysial elongation of the ischium is similar; but the small elongated triangular pubis of the crocodile is very unlike the broad reniform bone convex in front seen in *Plesiasaurus*.

The limb-bones of the two groups have no character in common.

#### § 4. *The Chelonian Characters of Plesiosaurus.*

There is considerable resemblance of form between the outlines of the skulls of some Plesiosaurs and some chelonians. And in both the temporal fossæ are large (except in marine Chelonia), and only divided from the circular orbits by a narrow post-frontal bone. The orbits of chelonians are more vertical, and are wanting in superior orbital and lachrymal bones. The anterior nares are near to the orbit; but they have a single termination, and the skull has no extension anterior to them; so that all the preorbital part of the chelonian skull is unlike, and not comparable with the plesiosaurian; the part behind the temporal fossa is

also dissimilar—Plesiosaurs having no auditory excavation of the quadrate and squamosal, or median backward prolongation of the parietal and superoccipital. Most living chelonians differ from Plesiosaurs in not having nasal bones.

The vertebral column has but little in common in the two types, either in the form of the centrum, the condition of its articular ends, the form of the neural arch, the attachment of the dorsal ribs, or the proportional lengths of the different regions; so that in no region of the column, either as a whole or in the separate vertebræ, is there any resemblance to *Plesiosaurus*, the chief differences being:—that in chelonians the cervical vertebræ are opisthocœlous, procœlous, and biconvex, but never biconcave; that the neural arch has no neural spine, no cervical ribs, and has the zygapophyses long and directed outward; while the under surface of the centrum is compressed, whereas in Plesiosaurs it is wide; the dorsal vertebræ are elongated, with flat articular ends, and have the rib articulating by a single head directly with the centrum, either between two vertebræ or at the anterior end; the caudal vertebræ have no neural spine in chelonians, and are procœlian or opisthocœlian.

The chelonian scapular arch has, at first sight, nothing in common with *Plesiosaurus*; but if the interspace between the coracoid and precoracoid were ossified in *Chelone*, two expanded coracoids meeting mesially would be formed, having a great resemblance to those of *Plesiosaurus*. And such a result might also be attained by continuous ossification of the coracoids with the hyosternal elements. Next it would be necessary to draw the scapulæ forward to be in the same plane with the coracoids. These, in the same way, might become continuously ossified with the clavicles; and the backward angle of the clavicle might be represented by the outer backward process sometimes seen on the plesiosaurian scapulæ. These bones would then take up the interclavicle between them inevitably in the position seen in *Plesiosaurus*, with its posterior angle internal to the coracoids, as it is internal to the hyosternal bones in chelonians.

The pelvic arch is more like that of *Plesiosaurus*. The ilium is similar, except that it is curved and the sacral end is more expanded. The pubis has a similar large expansion in *Chelone*, but not a kidney-shape. In the Tortoise the pubis meets the ischium in the symphysis as in *Plesiosaurus*, and the ischium has a subtriangular form and is directed backward; but it is not in the

same plane with the pubis, being directed somewhat downward.

As with the fore limb, so here the pubis might be supposed to combine with the hyposternal, the ischium with the xiphosternals. The plesiosaurian limbs are only comparable with the marine type. The chelonian femur differs chiefly in being shorter, less expanded distally in antero-posterior extent, and in having a large trochanter behind the proximal articulation. The humerus is somewhat similar distally, but not enough expanded; the bone is too short, and the trochanters at the proximal end are dissimilar. The tibia, fibula, ulna, and radius in chelonians are elongated, and so are incomparable. The carpal and tarsal bones are not dissimilar individually; but their arrangement is not like that in *Plesiosaurus*. The phalanges are not dissimilar in form, except that in *Chelone* the bones are vastly more elongated and much less numerous; but the hour-glass shape and flattened articular ends are similar.

#### § 5. *The Lacertian Characters of Plesiosaurus.*

The general outline of a lizard's skull is the same as that of *Plesiosaurus*; and in such a lizard as *Iguana* the orbits and temporal fossæ are similarly placed. But in *Plesiosaurus* the nares are further back and smaller; and thus the nasal bones are narrowed to extend between them, and the premaxillary bones enlarge to form the prenasal part of the skull. In *Iguana* the postfrontal is divided, but the superorbital part does not exclude the frontal bone from the orbit as in *Plesiosaurus*; but the back of the orbit is similarly formed by its postorbital part. In lizards the maxillary bone is not admitted into the base of the orbit as it is in *Plesiosaurus*. The parietal is similarly compressed into a longitudinal ridge, and similarly sends off processes behind which diverge outward and backward. The processes in *Plesiosaurus* appear to be overlapped by the squamosal bones, while in lizards the squamosal bones are overlapped by them. In lizards the quadrate bone is naked at the sides; but in *Plesiosaurus* it is covered by the squamosal and quadrato-jugal. And in Plesiosaurs the occipital segment of the skull is not prolonged beyond the parietal segment.

The teeth differ from those of lizards in being placed in sockets and in the series being similar from the back of the jaw to the front.

The palate of lizards differs in not being entirely closed mesially, in the totally different condition of the posterior nares, in the small size of the transverse bone, in the teeth on the pterygoid bone &c., and by the pterygoid bones not meeting to cover the basisphenoid. The occipital condyle is made to a less extent in lizards by the basioccipital bone than in Plesiosaurs.

The Plesiosaurian lower jaw has not the prominent coronoid process or the inward extension of the articular bone of Lizards.

The vertebral column of lizards like the *Monitor* includes as many vertebræ as in *Plesiosaurus*; only, instead of being chiefly in the neck and tail, they are chiefly in the tail, and the neck has only about half a dozen.

In *Monitor* and all lizards except the Gecko the centrum differs in its elongation and procœlous articulation. [The skeleton of a Gecko I have not seen.] The cervical vertebræ moreover differ in often having a strong hypapophysis. The dorsal vertebræ differ in the lateral extension of the zygapophyses, the absence of transverse processes, and the articulation of the ribs to the side of the centrum. The caudal vertebræ differ in having the chevron bones attached to the base of the centrum or its posterior margin, though there are a few Plesiosaurs (of undescribed species) in which this character is seen. The dorsal ribs of lizards are very like those of *Plesiosaurus*; but no lizard has similar abdominal ribs.

Neither pectoral nor pelvic arches have much in common with *Plesiosaurus*. In order to make the pectoral arch like that of a Plesiosaur, it would be necessary to blend the clavicles and interclavicle and contract the triradiate limbs of the latter bone till the scapulæ were nearly drawn together anteriorly, and the acromion became a terminal process at the free end of the bone. Then, by suppressing the sternum, the coracoid bones would come together mesially, and it would only be necessary to make a continuous ossification over the interspaces of the coracoid to have a pelvic arch essentially that of a Plesiosaurian.

In the same way, by expanding the lizard-pubis on its anterior border to a convex outline which should make the bone reniform and lie in one plane, and by then drawing the bone back to meet the ischium at the symphysis and rounding off the angles and ridges of the ilium, the pelvic arch would approach the plesiosaurian type.

In the limbs there is nothing in common.

§ 6. *The Rhynchocephaloid Characters of Plesiosaurus.*

The skull of *Hatteria* has much such an outline as that of *Plesiosaurus dolichodeirus*; and in the parietal and frontal regions there is a similarity of form; but in *Hatteria* the postorbital bone meets the squamosal, and forms an upper bar to the side of the temporal fossa, which does not occur in *Plesiosaurus*. The orbits in *Hatteria* are larger and more vertical than in *Plesiosaurus*, while the nares are lateral, and the premaxillary bones are developed anterior to them only to a small extent; the skull also appears to differ from that of *Plesiosaurus* in having all the median roof-bones double. The under surface of the palate differs from that of *Plesiosaurus* in not being closed in the median line, in not including divided nares at the back of the palate, in the large development of the pterygoid bones, which do not cover the basisphenoid, but extend along the inner wing of the quadrate bone, and extend forward to meet the vomers, while the palatine bone occupies the same lateral position between the pterygoid and maxillary which would entitle it to be considered homologous with the transverse bone in *Plesiosaurus*. The teeth are utterly unlike those of *Plesiosaurus* in form, in being blended with the jaw, in being also carried on the palatine bones.

The vertebral column differs from *Plesiosaurus* in the fewness of the vertebræ; though each vertebra agrees in having a not dissimilar form and a biconcave centrum. The atlas and axis are not like those of *Plesiosaurus*, the latter bone having an extended neural spine and an odontoid process. The fourth vertebra has a divided attachment for the ribs such as is sometimes seen in the cervical vertebræ of Plesiosaurs; but the cervical ribs have not the hatchet-shape. In *Hatteria* the intervertebral wedge bones are continued down the neck, which does not happen in *Plesiosaurus*. It has seemed to me to be not improbable that the conversion of amphicelous vertebræ into procœlous or opisthocœlous vertebræ has been determined by the ankylosis of the intervertebral wedge bones to the anterior or posterior margin of the centrum. In the dorsal region the ribs are supported by single heads, as in *Plesiosaurus*, but not from transverse processes. The caudal vertebræ carry chevron bones: the centrum differs from that of *Plesiosaurus* in being ossified in two parts. The cervical and

early dorsal ribs differ from those of *Plesiosaurus* in carrying an epipleuron, though the superior process which gives the cervical rib its hatchet-shape in *Plesiosaurus* may be regarded as an ankylosed epipleuron. The abdominal ribs of *Hatteria* are like those of *Plesiosaurus*; and in one species (for two species seem to me to be typified by the abdominal ribs figured by Dr. Günther) the median  $\Delta$ -shaped bone is overlapped by a splice from a bone external to it. In another species this splice is replaced by a joint, and the external piece has a squamous expansion on the middle of its anterior and posterior margin, unlike any thing seen in *Plesiosaurus*. But, as in *Plesiosaurus*, other bones are introduced between these elements, so as to make the abdominal ribs nearly twice as many as the costal ribs.

The pectoral girdle differs from that of *Plesiosaurus* in having a sternum and clavicles. Between these the interclavicle is ankylosed. The coracoid differs in its great extension in front of the acetabulum, in its small size, in its connexion with the sternum, in its wide union with the scapula. And only by revolving the scapulæ forward till they meet in front and are in the same plane with the coracoids, and at the same time causing them to grow distally at the expense of the sternum so as to obliterate it, could the rhynchocephalous pectoral arch be brought into harmony with that of *Plesiosaurus*.

The pelvis differs chiefly in its smaller size, in the ischium of *Hatteria* having a prominent posterior tuberosity, in the small size of the os pubis, which has not a reniform outline or a convex anterior margin, and in the compression of the ilium.

#### § 7. *The Ophidian Characters of Plesiosaurus.*

The points of resemblance between serpents and Plesiosaurs are so trifling that they may be neglected. In *Python* there is a parietal crest. A superorbital bone excludes the frontal from the orbit; and a narrow nearly vertical postfrontal makes the boundary of the orbit behind, as in *Plesiosaurus*. There are remarkable differences in that the squamosal and quadrate bones are loose, and that the bones of the face and palate are loose. The malar and quadrato-jugal bones are absent, and the side of the quadrate bone is naked; the premaxillary is minute, and the skull has no extension anterior to the nares; a considerable interval separates orbit and narine; and there is no temporal fossa; the maxillary bones are very long, and on their inside the pterygoids run par-



allel with them at the hinder part; the palate is mesially open. There is no resemblance in the vertebral column.

§ 8. *The Urodelan Characters of Plesiosaurus.*

The skull of the *Menopome* or of the Salamander has no striking resemblance to *Plesiosaurus* in any region; while the absence of a prenasal extension, the confluence of the orbit and temporal fossa, the two occipital condyles, the median bone (parasphenoid) at the base of the skull, the absence of covering bones from the quadrate bone, and the absence of socketed teeth would readily distinguish them.

The vertebræ agree in having the centrum biconcave; but the Urodelan centrum is much longer, and its neural arch wants the long compressed neural spine of *Plesiosaurus*. The cervical vertebræ are very few, and have transverse processes, which are not seen in *Plesiosaurus*, while the amphibians have usually no atlas.

The dorsal vertebræ agree with Plesiosaurs' in having transverse processes, which, however, are not given off exclusively from the neural arch, are compressed and directed obliquely backward. At their termination in some types the parts contributed by the neural arch and by the centrum divide so as to make a double attachment for the rib. The costal ribs differ in being double-headed and extremely short, while no sternal or abdominal ribs are developed. The caudal vertebræ differ additionally in having their chevron bones ankylosed to the base of the centrum.

The pectoral girdle differs in having the scapula and coracoid united in one ossification, and in the coracoid portions being divided by a wide cartilage. The scapulæ have no tendency to approximate anteriorly.

The ilium is not unlike that of *Plesiosaurus*. The bone inferior to it is usually named the ischium; but if these bones were revolved forward so that the median line became anterior, and the bones met mesially at their posterior borders, then they would have the position, as they already have the shape, of the pubic bones of *Plesiosaurus*.

In the limbs there is some resemblance; but the shaft of the humerus and femur is not sufficiently expanded, and the proximal trochanter should not have been severed from the head of the bone, the forearm and foreleg are too long; and the ulna and tibia are not reniform; the carpals and tarsals are more irregular in size, and have

a tendency to form three rows ; while the bones of the digits differ chiefly in the small number of bones in each, and in there being four digits on the hand and five on the foot.

The Anatomy of two Parasitic Forms of the Family Tetrarhynchidæ. By FRANCIS H. WELCH, F.R.C.S., Surgeon, Army Medical Department, and Assistant Professor of Pathology, Army Medical School, Netley. Communicated by Professor BUSK, V.P.L.S.

[Read May 6, 1874.]

(PLATES XXIV.--XXVI.)

THESE two forms of the Tetrarhynch family, suborder Cestoda (*Cobbold*), among parasites, were obtained from the stomach of a Shark (*Carcharias* —— ?), and transferred to me by Dr. Macdonald, R.N., F.R.S. Of the larger form there were three specimens, of the smaller five ; and with them was a portion of the shark's stomach, to which one of the larger forms was attached, the rest of the parasites being loose in the alcohol in which the whole mass was preserved.

The mucous membrane of the stomach was irregularly superficially ulcerated in spots to the size of a shilling ; and narrow channels diverged from the surface of the ulcer into the subjacent tissues to the depth of  $\frac{8}{100}$  to  $\frac{15}{100}$  of an inch, these channels generally being arranged in pairs and evidently produced by the proboscides of the parasites for anchoring themselves ; while with some there was also a broader pit, from which the channels diverged, produced by the partially immersed head of the creature. Around these channels for at least  $\frac{1}{2}$  an inch there was marked dark discoloration of the tissues from blood-extravasation and disintegration. One of the larger forms was still attached ; but since the stomach had been cut into pieces it had moved ; for it was now anchored to the fresh incised surface. No part of the head of the parasite was inserted into the stomach-coats, so that the suckers were not called into action ; but the proboscides diverged from each other into the tissues, having a broad base of attachment ; and a considerable application of force relative to the size and strength of the tissues of the creature was used without the anchors giving way.

Whether these forms of animal life are new to science or have